

Living characteristics of rare and endangered species — *Davidia involucrata*

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Abstract: Dovetree (*Davidia involucrata*), one of the first-class protective plants in China, is a relic species of paleotropical kingdom in Tertiary period, belonging to *Davidiaceae* with a single genus. In recent years, the increase of regional developing projects has led to a sharp decrease of this ancient and rare plant in naturally distributed habitats and natural population. In this paper, the biological and ecological characteristics of Dovetree were described, and the geographically distributed condition of this species in different geologic periods as well as the major reasons for dynamic changes of its population were systematically analyzed in accordance with field researches and references. The investigations conducted in different years by setting up standard sample plots showed that the population number of Dovetree increased yearly in the areas without human interference but decreased yearly in the areas with human interference. With the increase of population density and human activities decreased as the logarithmic curve: $Y = -100.7\ln(x) + 178.09$, and it has turned from a dominant population into an endangered population. Based on the former and present studies on Dovetree, some protection strategies were put forward for protecting this ancient and rare species.

Key words: *Davidia involucrata*; Dovetree; Geographical Distribution, Biological Characteristics, Protection Policy

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Introduction

Dovetree (*Davidia involucrata* Baill), which is rated as the first class protective plant in China, is a tertiary paleotropical kingdom relic species rare to China (Fu 1992). It belongs to *Davidiaceae* with a single genus, and its systematical position is relatively solitary. Dovetree is usually regarded as a "Botanic Living Fossil" and also called Chinese dove tree, because its capitulum with two beautiful bracts is exactly like a flying dove (Yang 1986; Zhang 1988). Southwest of China is the original place of the Dovetree (Tao 1986; Zhang, 1992; Zhang 1995). In 1869, Armond David, a French priest, found a solitary tree in Muping of Sichuan Province. He delivered articles and regarded that Dovetree was distributed only in Muping and Shennongjia (Wang 1995); nevertheless, the correctness of this report was doubtful because of the hard transportation in Southwest China (He 1995). In 1904, Qi'an Company of the United Kingdom delegated Wilson to collect this rare tree and made an exploratory search in Southwest China. He fully completed the task and presented it to Anderrow Arboretum of Harvard University. Wilson also delivered a masterpiece of Mother of Chinese Gardens (Zhang

1994, 1995). In 1921, New York Nature Museum of America delegated persons to collect seeds and specimen of rare flowers and rare plants in China. They transported some Dovetree seedlings back to America and planted them in White House (Zhang 1995). In June of 1954, Chinese Premier Chou Enlai thought highly of the beautiful scene of Dovetree in bloom during Genevese Meeting. When he learned that its ancestral home was China, he directed Chinese forestry researchers to carry out the research and propagation of Dovetree (Yang 1980). However, up to date, the research on this rare species has been still being in the beginning phase because of lacking ecology and environment data. In this paper, we discussed the biological characteristics of Dovetree, systematically analyzed the natural and artificial disturbances in different geologic periods to its survival, and probed into conservation policy on this species. The objective of this paper is to provide basic data such as phenology, regeneration and community characteristics, for intensively studying and introducing the rare species, protecting species resources and genes, and all of relic species in Southwest of China.

Biological and ecological characteristics

Biological characteristics

Dovetree is low-rooted lofty defoliated arbor tree. Its average height is 10~25 m, and the maximum height reaches to 30 m. DBH (Diameter at Breast Height) can reach 1.0-1.5 m. Dovetree is a hygrophilous plant species. Before the age of 10, it does not have obvious taproots and branch

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roots, and its root system is greatly distributed in 10-20 cm layer of soil. When Dovetree is fifteen to thirty years old, its taproots only reach 0.8-1.5 m in length and branch roots compress 30-70 cm soil. The root's distributing breadth is about 10-15 cm (Wang 1993). Dovetree begins to bloom when it is 6-8 years old, fruit at age of 10-15, with a fruiting peak at age of 30-90, and for isolated cases, some individuals even bloom and fruit at age of over 100 years. The leaf buds of natural individuals sprout in the last ten-day of February, enlarge in the first ten-day of March, completely outspread in the last ten-day of March, begin to grow in the middle ten-day of April until the middle ten-day of May (The length of leaf stalk is 4-8 cm, the width of leaf surface is 9-16 cm); spring cycle shoots grow in the middle ten-day of April until the first ten-day of July (the length is 20-55 cm), fall cycle shoots of exceptional individual grow in the first ten-day of August until the first ten-day of October (the length is 5-10 cm). The blooming period ranges from the middle ten-day of April to the middle ten-day of May. Two bracts are upstanding: one is usually 10-15 cm in length and 7-10 cm in basal width, and the other is 4-8 cm long and 3-5 cm in basal width. Along with bracts' growth and seeds' formation, foot stalks cannot support the weight of bracts and seeds. Therefore, at this season, foot stalks are pressed bending, bracts droop and the color of bracts change from light green to white. Under the sun, a bract is blown by the wind like doves dancing, so the plant is called Chinese dove tree. After 10-15 days, bracts fell off. The length of big bract is 10-25 cm and that of small bract is 7-15 cm. The blooming period is about 40-50 days (Sen 1993; Xiang 1989).

Community composition and structure

The distribution area of Dovetree had a great change in elevation, so the species composition of Dovetree forest is very different. There are more evergreen broad-leaved varieties at the lower limit of its distribution. *Castanopsis* sp., *Machilus* sp., *Lithocarpus* sp. are popular. And many defoliated broad-leaved trees such as *Acer* sp., *Sorbus* sp., *Prunus* sp. distributes at its upper limit.

Communities dominated by Dovetree are usually found in mountain valleys at elevations of 1300-1500 m. The color of the community is viridian, while in winter yellow brown and rifle green are mixed. Arbor layer, shrub layer, and herbaceous layer are distinct in this kind of community, and the canopy density of Dovetree forest can reach 0.7.

The arbor layer can be divided into two sub-layers. The upper layer, about 10-25 m high, is predominantly made up of defoliated broad-leaved trees, such as *Davidia involucreta* which is dominant, *Strax hypoglauca*, *Liquidambar acalycia*, and *Pterostyrax psilophylla*. The community also includes *Aesculus wilsonii*, *Tetracentron sinensis*, *Betula insignis*, *Acer davidii*, *Acer sinense*, *Acer palmatum*, *Juglans cathayensis*, *Carpinus fagiana*, *Fagus logipetiolata* etc. There are evergreen broad-leaved trees in the upper arbor layer, but their tree crowns are lower than Dovetree's, for

example, *Castanopsis hunii*, *Cyclobalanopsis oxyodon*, and *Lithocarpus* sp. are prevalent. The proportion of evergreen broad-leaved trees in the lower arbor layer greatly increases, but they are frequently little arbors such as *Camellia cuspidata*, *Symplocos stellaris*, *Eurya* sp., *Camellia pitardii*, *Michelia* sp., *Sorbus* sp. and the seedlings of upper-layer arbors. The species of *Styrax hypoglauca* or *Pterostyrax psilophylla* of *Styracaceae* in the arbor layer is well developed. The tall *Pterostyrax psilophylla* can be regarded as a reference species to find *Davidia involucreta*.

The shrub layer, with a coverage degree in range of 30%-60%, is composed of the species: *Litsea* sp., *Lindera glauca*, *Lindera fragrans*, *Euonymus alatus*, *Rubus peltatus*, *Mahonia bealei*, *Weigela japonica*, *Callicarpa cathayana*, *Stachyunus chinensis*, *Dichroa febrifuga*, *Sambucus williamsii*, *Hydrangea chinensis*, *Ilex cornuta*, *Biburnum* sp., *Aucuba chinensis* etc. There is also *Sinarundinaria* sp. and *Rhododendron* sp. at the higher altitude.

The herbaceous layer, with a coverage degree of lower than 30%, is often occupied by skiophilous and hygrophilous plants, such as *Dysosma versipellis*, *Panax transitoxinus*, *Arisaema rhizomatum*, *Dryopteris* sp., *Arthraxon hispidus*, *Reineckea carnea*, *Rohdea japonica*, *Parix polypylla*, *Pilea* sp., *Elatostema* sp., *Oxalis griffithii*, *Catex* sp., etc. Interlamellar plants are lichen, *Pyrrosia* sp., *Dendrobium* sp., *Schisandra* sp., *Celastrus* sp., *Cayratia japonica*, *Smilax* sp., etc.

The remarkable characteristics of Dovetree community is that it includes many archaic and rare plants, such as *Davidia involucreta*, *Tetracentron sinensis*, *Carpinus sinense*, *Actinidia chinensis*, *Celastrus* sp., *Fagus logipetiolata*, *Aesculus wilsonii*, and *Panax transitoxinus*, etc.

Habitat and regeneration

Dovetree grows in the valleys in which relief types are complex, relative relief is great, and erosion is serious; or grows in the shady slope of round hill on which hypso-graphic feature is slow, and relative relief is small. The Distribution area of Dovetree is characterized in climate by cold winter, cool summer, less rain in winter and spring but spate in summer and fall, dense fog in foggy days, and great humidity in the forest. This indicates that Dovetree is a cold-resistant, cool-loving, shade-tolerant and moist climate-enduring species in sub-tropic area. It can grow in many soil types: mountain yellow soil, mountain yellow brown soil, brown soil, red and yellow soil. Still in acidic (pH=4.5~6.0), moist, loose and fertile soil with thick humus, granular structure, Dovetree also grows well (Liu 1987). Dovetree has sprouting habitats. It will produce many coppice sprouts from neck of spermatozoon if the normal individual is hurt. In wild type, Dovetree regenerates from seeds and coppice sprouts, but mainly from seeds. Only when seeds sprout do animals feed on them, as its nut is hard. Therefore the retention of natural seeds is possible. Our data showed that seeds of Dovetree stored in ventila-

tive condition, did not germinate, while the germination of those seeds stored in the wet sand was promoted or accelerated. However, in China, most of distribution areas of Dovetree are dry, and it is difficult for Dovetree to sprout, as a result, its natural propagation is restricted. Only in the bottom of deep-cutting valley, where the soil environment was improved, the Dovetree may have chances to propagate by seeds. In this condition, other tree species cannot be in normal development. This decreases the competition between Dovetree and other tree species. And in the community with a medium canopy density, the Dovetree could regenerate successfully if the seed sources are rich. One of the major endangering reasons for this species is that its reproduction requests suitable sunshine condition and soil humidity and that wild seeding are excavated.

Natural and artificial disturbance

Dovetree in different geological times

Angiosperm was well developed from the late cretaceous period to Tertiary period. Dovetree was developed at the same time and its Distribution reached Yellow River basin at N 37°-38° in the early Tertiary period. After the miocene epoch, climate turn cold gradually. At that time, the flora was like the today's (Wu 1979; Group of Sichuan Vegetation 1980). To the late Tertiary period, northeast of Yunnan Province and Southwest of Sichuan Province became a whole body on topography, which was "peneplain". Vegetation was an intact flora. Dovetree possibly distributed throughout this area, even the major vegetation type on the shady slope. Dovetree was widely ranged in the world (Wang 1995). To the early quaternary period, Earth experienced some glacial periods. The high latitude and middle latitude of the northern hemisphere were widely covered by continental glaciers and mountainous glaciers. Even Jiangsu and Zhejiang provinces of China were cov-

ered by the mountainous glaciers of Quaternary Period. A lot of vegetation disappeared due to the glaciers of quaternary period and global temperature drop. Dovetree died out in many place (Zhang 1992), and survived only in subtropical mountain of the Southwest China because of complex topography and weak impacts of the glaciers of Quaternary Period. This is why the Dovetree is called living fossil (Zhang 1992) and direct descendant of flora of the Tertiary Period (Group of Sichuan Vegetation 1980). In 1869, French Armand David found Dovetree in Muping in Baoxing County of Sichuan Province. And Dovetree is named as *Davidia involucrata* by Baillon H.E. Botanists at that time were greatly concerned with this tree species. After that Euramerican scholars came to China to gather seeds. So Dovetree is viewed as a rare and famous ornamental plant of gardens.

Through the analysis of palynology and history data (Group of Sichuan Vegetation 1980), after the Quaternary Period, global temperature increased, the distribution of Dovetree increased only in the sewerage of mountainous area in the Southwest China. Up to the late 19th century, the distribution of Dovetree stretched from Qingzhen County in Guizhou Province at 26°46' N to Wen County in Gansu Province at 32°43' N and from Gongshan County in Yunnan Province at 98°6' E to Changyang County in Hubei Province at 111°20' E. Now Dovetree is distributed in seven provinces (Gansu, Shanxi, Hubei, Hunan, Sichuan, Guizhou and Yunnan) and over 40 counties (Shi 1986; Qi 1990) (Fig. 1). Nevertheless, in the 20th century, human activities destroyed the natural forest ecosystem and plant habitat, which has led to a sharp decrease of natural distributed area and natural population number of this ancient and rare plant. Dovetree is presently in severe danger (Zhong 1984; Wu 1985).

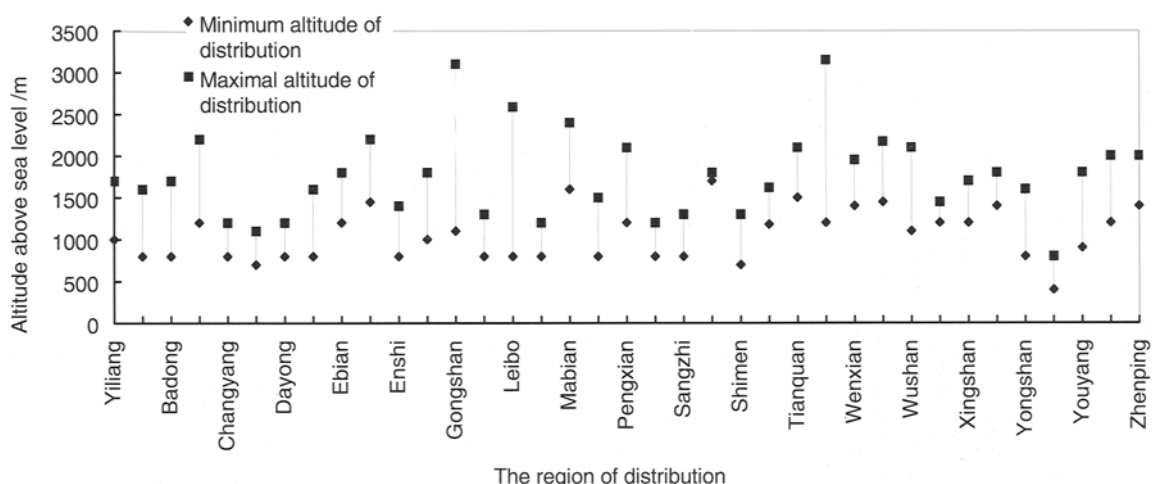


Fig. 1 The vertical distribution pattern of *Davidia involucrata*

The effects of human activities on Dovetree

Since the extinction of dinosaur 65 million years ago, the loss of biodiversity is faster than any other time. It is estimated by scientists that at present speed about 5%-10% of tropical forest species possibly die out in the next 30 years. The investigations on dovetree in different years by standard sample plots showed that the population number of dovetree and its reproduction condition are in depression following the increase of population density and human activities (Fig. 2 and Fig. 3).

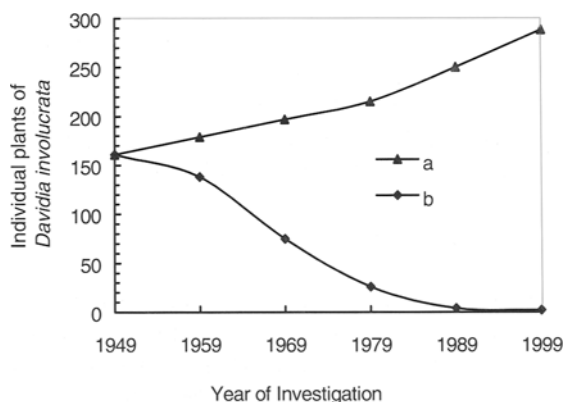


Fig. 2 Change condition of *Davidia involucreta* Baill's population number in two test plots in Fanjingshan in Guizhou Province of China.

This figure showed the difference of dovetree's population number and reproduction with and without intense human interference in 50 years. Curve a and b separately represents the individual plants in five gouges without and with human interference. The area of sample plot is 2400 m² for each kind of investigation.

From Fig. 2, we can see that without artificial interference Dovetree population belongs to spreading population. The individual number of population increases as the exponential curve: $Y = 141.38e^{0.1142}$ ($R^2 = 0.9890$). Dovetree's population is in severe depression under the intense artificial interference. The individual number of population decreases as the logarithmic decrease curve: $Y = -100.7\ln(x) + 178.09$ ($R^2 = 0.9349$). Dovetree population is in severe danger due to the intense interference. This species is sensitive to exterior environment, and the stability of this community is fragile. The major reason for the sharp decrease of recent distribution area of Dovetree is that environmental changes lead to the difficulty of natural regeneration.

From the above analysis, with the increase of people population density, population number of Dovetree decreases as the logarithmic curve: $Y = -100.7\ln(x) + 178.09$ and Dovetree population depressed from dominant population to endangered population. Meanwhile, the population numbers of most ancient species decrease at a high speed because of the habitat destroy. It becomes the major purpose to protect the ancient species through establishing

natural conservation area.

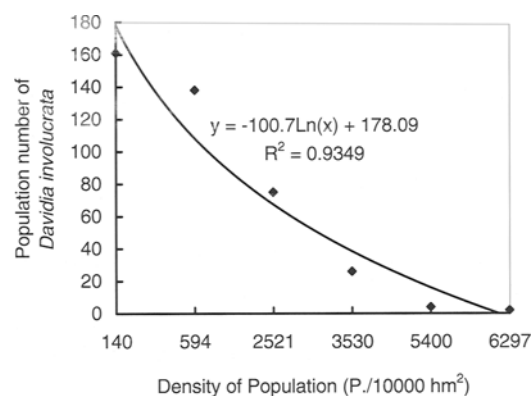


Fig. 3 The relationship between population density and changes of *Davidia involucreta* Baill population in intense human interference area

Survey area: 2400m², survey timespan is ten years (1949, 1959, 1969, 1979, 1989, 1999)

How to protect Dovetree: Conservation Policies

It is well known that Dovetree is the famous ornamental plant in the world. Introduction and cultivation of Dovetree in the foreign countries were carried out in the late 19th century. Now Dovetree in Genevese of Switzerland and White House are in bloom and fruiting. China began introduction of Dovetree from the 1960s, including 11 provinces: Yunnan, Sichuan, Hunan, Hubei, Anhui, Zhejiang, Jiangsu, Henan, Shanxi, Shanghai and Beijing (pot culture). From 1988 to 1990, three hetero institutional forests were established: Lijiazai Experimental Area in Jigongshan National Nature Conservation Area in Henan Province (4 hm²), Houhe Forestry Centre in Wufeng County of Hubei Province (13.3 hm²), West Tianmu Mountain Forest Science Institute in Lin'an County of Zhejiang Province. Rate of survival can reach 80%.

In addition to study on experimental forest for allopatric and cultivated species, an emphasis should be put on the natural habitat of Dovetree. Dovetree conservation for allopatric and cultivated species has already lost many intrinsic genetic biodiversity. While stem planting is just the transfer of genetic materials. Therefore, to protect species diversity and genetic diversity of Dovetree, firstly it is to protect its natural habitat. The purpose of protecting biodiversity is to protect and utilize biological resources through non-decreasing species diversification or nondestroying important habitats and ecosystems. Aiming at ancient populations, this process should embody three basic compositions: saving biodiversity of Dovetree's community, analyzing sustainability of biodiversity of Dovetree community, and reasonably utilizing this rare ornamental plant. Saving biodiversity of Dovetree community is to protect

gene, species, habitat and ecosystem. The best measure for protection of this rare species is to protect its habitat. Therefore, the key problem to protection on the spot is to prevent retrogression of natural ecosystem, decrease human activities in natural habitat, and effectively manage the conservation area. For this reason, we put forward five protection strategies of ancient species, especially the Dovetree.

(1) Establish national policy to improve sustainable utility and protection of special habitat of rare ancient species (especially *Davidia involucrata*). Energetically develop the efficiency of utilizing biological resources.

(2) Create local communities to protect the population of ancient species, especially Dovetree. Band Dovetree's individual protection, population protection, community protection, ecosystem protection and habitat protection. Combine protection with scientific research. Bring the living law of ancient species.

(3) Establish a stable society, i.e. background to protect ancient population. Only under the background of material change from destroying population distribution to sustainable living, can we ensure adopting tactics to protect the ancient species.

(4) Protection strategies commonly fall into two broad categories: simply allowing relatively natural vegetation and ecosystems to acts as nature reserves by keeping land and vegetation management; intentionally setting aside protected areas to act as designated nature reserves. Under the hypothesis of protecting its genes and biological characteristics, combine these two protection strategies to increase its living adaptability to habitat and to widen ecological behavior.

(5) Strengthen environmental consciousness, increase public participant capability, and combine landscaping with introducing Dovetree.

At the same time, it is very necessary to impose restriction on picking seeds to ensure the normal reproduction of Dovetree, otherwise, it will lead to the decrease of distribution area, increase the possibility of inbreeding, and destroy the life force of Dovetree population. The results of vicious circle inevitably lead to the loss genetic diversity. Therefore, we should to establish naturally reserved area on the spot to protect Dovetree and its community. Do not loosen the protection work of native habitat because of its wide introduction. Governments in China at all levels have established Dovetree reserves in many places, among which some is national reserves, even global reserves. At present its protection is ensured. Still as Dovetree is an ancient species, many biological characteristics of it limit its enlargement; moreover it has a weak competitive ability with other trees. Cutting Dovetree must leads to the sharp decrease of population number, even possibl to die out. Much is for its own condition: its testa is hard, endosperm is easy to sop, and its afterripening period is long. Under the natural condition, it takes over two years to germinate. Most of seeds are eaten by animals before they germinate. Its

seeds germinate only on the edge of forest and in humid climate. Many people dig up natural seedlings. All of these threaten its survival and development. For this purpose, it is very essential to strengthen management of natural reservation area, for example, Shennongjia in Hubei province, Mulinzi in Hefeng County, Xingdoushan in Lichuan County, Houhe in Wufeng County, Wolong in Wenchuan County, Dafengding in Mabian County, Dafengding in Meigu County, Small Zaizigou in Beichuan County, Baishuijiang in Wen County in Gansu province, Fanjingshan in Jiangkou County in Guizhou province, Badagongshan in Shangzhi County in Hunan, Huping in Shimen County, Gongshan in Gaoli County in Yunnan province, Sanjiangkou in Yongshan County and Haiziping jin Yiliang County. Meanwhile, we should emphasize protection in non-native habitat. That is to say: strengthen the introduction of *Davidia involucrata*, enlarge its distribution area, and relieve the threats caused by its deficient propagation capability and human affection.

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